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Physical, Sensory and Microbiological Properties of Wheat-Fermented Unripe Plantain Flour

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ABSTRACT

The physical, sensory and microbiological properties of wheat-fermented unripe plantain composite flour bread were studied. Mature unripe plantain was peeled, sliced, steam blanched, dried and milled into flour. The flour was made into a slurry (10 g of flour/3 ml of water) and allowed to ferment for 24 h. It was then dried, pounded and sieved through 0.25 mm sieve. The fermented unripe plantain flour was then blended with wheat flour in the ratios of (wheat:fermented unripe plantain) 100:0; 90:10; 80:20; 70:30; and 60:40. Bread was produced from the flour blends using the straight dough method. Loaf weight and volume decreased significantly ($p < 0.05$) with increasing levels of plantain flour inclusion. Sensory evaluation of the flour samples revealed significant differences in the ratings for crumb colour and texture between 100% wheat flour (100:0) and 60% wheat-40% fermented unripe plantain flour (60:40) bread but no significant difference was observed between all bread samples with respect to crust colour, taste, aroma and overall acceptability. The sensory scores showed that all the bread samples were acceptable. Microbiological analysis (total viable count) revealed that all the bread samples were free of microorganisms for up to four days after production.

Keywords: Plantain, slurry, fermented, bread, sensory properties.

Introduction

Bread is the loaf that results from the baking of dough which is obtained from a mixture of flour, salt, sugar, yeast and water. Other ingredients like fat, milk, milk solids, sugar, egg, anti-oxidants, etc. may be added. Bread is an important staple food whose consumption is steady and increasing in Nigeria. It is however relatively expensive because it is made from wheat flour which has to be imported (Edema *et al.*, 2004). Efforts have been made to promote the use of composite flour in which flours from locally grown crops replace a portion of wheat for use in bread, thereby decreasing the demand for imported wheat and producing protein enriched bread (Giami *et al.*, 2005). Although there is now a substantial amount of available composite bread technology, such breads still require at least 70 % of wheat flour to be able to rise (Eggleston, 1992). The predominance of wheat flour for baking of aerated (leavened) breads is due to the properties of its elastic gluten protein, which helps in producing a relatively large loaf volume with a regular, finely vesiculated crumb structure. If the wheat flour used in bread making is to be substituted with flour produced from other crops, it must be milled to acceptable baking quality. However, such products cannot compare favourably with wheat flour product and, therefore, can only be referred to as non-wheat bread or named after their flour sources (Opara *et al.*, 1991).

Plantain *(Musa paradisiaca)* belongs to the family of banana and is popularly called cooking banana since it is seldom eaten raw. It is widely grown in the southern states of Nigeria where there is adequate

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rainfall distribution (Oyenuga, 1972). However, about 35 – 60 % of the plantain produced annually is lost post-harvest due to poor infrastructure (Olorunda and Adelusola, 1997).

Food fermentation is regarded as one of the oldest ways of food processing and preservation. Man has employed the use of microbes for preparation of food products for thousands of years and all over the world a wide range of fermented foods and beverages contributed significantly to the diets of many people (Achi, 2005). In traditional fermented food preparation, microbes are used to prepare and preserve food products. Fermentation by desirable organisms impart flavour, bouquet and texture to the fermented foods adding to their nutritive value, flavour and other qualities associated with edibility (Ihekoronye and Ngoddy, 1985).

Acceptable bread from wheat-plantain composite flour can be formulated using up to 80:20 w/w ratios of wheat: mature green plantain flour (Mepba *et al.*, 2007). These authors further reported that increasing levels of mature green plantain flour (up to 50 %) had no significant effect on the oil absorption capacity, bulk density, and emulsion capacity and stability of the flours but caused the moisture, protein and fat contents as well as the specific volume of the bread to decrease while increasing the ash, crude fibre and carbohydrate contents of the bread. Ocheme *et al.* (2010) produced bread from wheat-fermented ripe plantain composite flour and recommended 30 % level of substitution of wheat flour with fermented ripe plantain flour for production of acceptable bread with a shelf life of about four days.

This work is aimed at determining the effect of inclusion of fermented unripe plantain flour in bread on the physical, sensory and microbiological properties of wheat-plantain composite flour bread with a view to increasing the level of plantain flour inclusion in wheat-plantain composite flour for bread production.

Materials and Methods

Source of raw materials

Hard wheat flour (Golden Penny Nigeria PLC), unripe plantain, bakers' yeast, granulated sugar, table salt, baking fat, vegetable oil and egg were purchased from Minna Central Market, Minna, Niger State, Nigeria. Production and analysis of the bread samples were carried out in the Food Science and Nutrition laboratory and the Microbiology laboratory of The Federal University of Technology, Minna, Nigeria.

Preparation of fermented unripe-plantain flour

A bunch of unripe plantain (plantain whose peel is green and whose pulp is not soft) was washed, peeled and cut into round slices of 5 mm thickness. The slices were steam blanched for 10 min. This was followed by drying in a hot air oven at a temperature of 80^{o}C for 24 h. The dried fruit was then milled and sieved using a 0.25 mm mesh. The flour was made into a slurry by mixing with distilled water in a ratio of 10:3 w/v (flour: water g/ml) and allowed to stand for 24 h so as to allow fermentation

Flour (wheat and fermented unripe plantain flour)

↓

Mixing (4 min at low speed and 6 min at high speed)

↓

dividing

↓

Intermediate proofing (30^{o}C for 2 h)

↓

moulding

↓

Final proofing (30^{o}C for 10 min)

↓

Baking (150^{o}C for 50 min)

↓

cooling

Fig 1: Flowchart for the production of bread from wheat-fermented unripe plantain composite flour

(uncontrolled) to take place. The slurry was then spread evenly on a tray and oven dried for 24 h at 60°C. The dry flour was then pounded, sieved (0.25 mm mesh) and packaged in a white high density polyethylene bag and stored in a refrigerator at a temperature of 4°C.

Formulation of blends

Wheat-fermented unripe plantain composite flours were formulated in the ratio of (wheat: fermented unripe plantain) 100:0; 90:10; 80:20; 70:30; and 60:40.

100:0 = 100% wheat flour

90:10 = 90% wheat flour and 10% fermented unripe-plantain flour

80:20 = 80% wheat flour and 20% fermented unripe-plantain flour

70:30 = 70% wheat flour and 30% fermented unripe-plantain flour

60:40 = 60% wheat flour and 40% fermented unripe-plantain flour

Production of bread using wheat-fermented unripe plantain composite flour

Bread loaves were produced using each of the formulated flour blends. The straight dough method of bread making described by Badifu and Akaa (2001) was used and is as shown in Figure 1. The proportions of the ingredients are shown in Table 1. The bread samples were packaged in 0.2 mm thick polyethylene bag and stored under ambient conditions (29 ± 1°C) for further analysis.

Table 1: Bread making ingredients (ratio)

Ingredient	Quantity
Flour	100 g
Water	56 ml
Yeast	1.25 g
Sugar	10 g
Margarine	2.5 g
Salt	1.5 g

Determination of physical properties of bread

The loaf volume and specific loaf volume of the bread samples were determined using the seed displacement method as described by Mepba *et al.* (2007), while the loaf weight was measured by means of an electronic weighing balance.

Sensory evaluation of bread samples

The bread samples were subjected to sensory evaluation about 1 h after baking by a semi-trained 15-member panel that was very familiar with bread. Degree of acceptance or likeness or preference was expressed on a 5 point scale where: 5 = very good; 4 = good; 3 = average; 2 = poor; and 1 = very poor. The sensory attributes evaluated were crust colour, crumb texture, crumb colour, taste, aroma and overall acceptability. The bread samples were served to each panellist on a tray in a random manner. With respect to taste, panellists were advised to rinse their mouth after tasting each sample and water was provided in plastic cups to each panellist for this purpose.

Microbiological analysis of bread samples

The total viable cells (total count) of micro-organisms present in the bread samples were determined on the day of production and every other day after production for 5 days using peptone water, potato dextrose agar and plate count agar.

Statistical analysis

The data obtained were statistically analyzed using one way analysis of variance (ANOVA) by means of MINITAB 14 statistical software.

Results and Discussion

Physical properties of wheat-fermented unripe plantain composite flour bread

Table 2 shows the loaf volume, specific loaf volume and loaf weight of the bread samples. Loaf volumes ranged from 420 to 702 cm^3. The whole wheat flour bread had the highest value and bread obtained from 60:40 flour having the least loaf volume. Loaf weights ranged from 148 to 169.2 g with bread made from whole wheat flour having the highest weight and bread made from 70:30 flour having the least weight. Specific loaf volumes ranged from 3.04 to 5.71 m^3 with bread made from 90:10 flour having the highest value and that from 70:30 blend having the least value. This is in line with the report of Okafor *et al.* (2012) for wheat-mushroom powder bread. The decrease in loaf volume, loaf weight and specific loaf volume as plantain flour levels increased is probably due to a decrease in the elastic property of the flours, which depends on the gluten content. The gluten content of flour enables it to trap the gas produced during fermentation, yielding higher loaf volumes and weights. It also results in finely vesiculated crumb structure. Since plantain flour has no gluten, its inclusion will cause a reduction in gluten content, hence the reduction in these physical properties of the bread samples. The result obtained for the loaf volume is in line with the reports of Mubarak (2001), Badifu *et al.* (2005), Mepba *et al.* (2007) and Agu *et al.* (2010), for wheat-lupin seed bread, wheat-mango mesocarp bread, wheat- matured plantain bread and wheat-fluted pumpkin flour bread respectively. Okafor *et al.* (2012) also reported decrease in loaf volume with increase in mushroom powder supplementation. The result obtained for all parameters is in agreement with that obtained by Ocheme *et al.* (2010), where wheat and fermented plantain composite flour was used to produce bread.

Table 2: Physical properties of bread samples

	Sample				
Parameters	**XYR**	**YBE**	**CQD**	**KOJ**	**PSA**
Loaf volume (cm^3)	702 ± 7.07^a	628 ± 4.24^b	540 ± 5.66c	452 ± 4.24^d	420 ± 2.83^d
Loaf weight (g)	169.2 ± 0.00^a	166.1 ± 2.97^a	160.0 ± 1.41^b	148.5 ± 0.00^c	158.5 ± 0.00^b
Specific loaf volume (cm^3/g)	4.15 ± 0.00^a	3.78 ± 0.00^b	3.38 ± 0.00^{cd}	3.04 ± 0.00^d	3.50 ± 0.00^c

Values are means standard deviation of triplicate determinations.

Means in the same row with different superscripts are significantly different ($p < 0.05$).

XYR = 100 % wheat flour
YBE = 90 % wheat flour and 10 % fermented unripe-plantain flour
CQD = 80 % wheat flour and 20 % fermented unripe-plantain flour
KOJ = 70 % wheat flour and 30 % fermented unripe-plantain flour
PSA = 60 % wheat flour and 40 % fermented unripe-plantain flour

Sensory properties of bread produced from wheat-fermented unripe plantain composite flour

The mean sensory scores of the bread samples are shown in Table 3. With respect to crust colour, bread made from 100:0 flour was the most preferred with a score of 4.06 while bread made from 80:20 flour was the least preferred with a score of 3.33. Crumb colour scores ranged from 3.13 to 4.13 with bread made from 100:0 flour being the most liked and bread made from 60:40 flour the least liked. For crumb texture, 100:0 flour bread was the most preferred with a score of 4.20 while 60:40 flour bread was the least preferred with a score of 3.33. The mean sensory scores for taste ranged from 3.46 (90:10 flour) to 3.93 (100:0 flour). For aroma, bread made from 70:30 flour was rated highest with a score of 3.73 while bread made from 60:40 flour was rated lowest with a score of 3.26. The overall acceptability scores ranged from 3.85 to 4.28 with bread from 100:0 flour having the highest score while breads from 70:30 and 60:40 flours had the lowest score. There were significant differences ($p < 0.05$) in the sensory scores of the bread samples (between 100:0 flour and 60:40 flour breads) with respect to crumb colour and texture. However, there were no significant differences ($p < 0.05$) in the sensory scores of all the samples for crust colour, taste, aroma, flavour and overall acceptability. The significant difference observed in the crumb colour and texture of bread samples made from 100:0 flour and 60:40 flour may be due to the high level of plantain flour in the latter sample which may have caused the crumb to be less finely vesiculated since plantain flour does not contain gluten which aids in the soft texture of bread crumb. This may have caused the crumb of the 60:40 flour bread to be crunchy which some of the panellists found appealing as some of them mentioned in their comments though most of them scored it lowest of all the bread samples. The lack of significance in the sensory scores of the bread samples with respect to taste, aroma, flavour and overall acceptability may be due to short fermentation time of the plantain flour since fermentation usually alters the taste and aroma (flavour) of foods. The result obtained for all parameters except overall acceptability is in close agreement with that reported by Mepba *et al.* (2007) and Ocheme *et. al.* (2010) for wheat-mature plantain bread and wheat-fermented ripe plantain bread respectively. With respect to overall acceptability of the bread samples, though 100% wheat flour was rated the best on all sensory attributes, all the bread samples were acceptable to the panellists. This implies that the fermented unripe plantain flour possesses similar sensory characteristics with wheat flour (Ogazi, 1998). The result obtained for overall acceptability is similar to the report of Olaoye *et al.* (2006) for substitution of wheat with mature green plantain but in contrast with the findings of Mepba *et al.* (2007) and Ocheme *et al.* (2010) where bread samples were unacceptable at 70:30 wheat-mature plantain and 60:40 wheat-fermented ripe plantain flour blends. Badifu *et al.* (2005) also reported low overall acceptability for bread produced from 30 % mango mesocarp flour substitution.

Table 3: Mean sensory scores of bread samples

	Sample				
Parameters	**XYR**	**YBE**	**CQD**	**KOJ**	**PSA**
Crumb colour	4.13 ± 0.23^{a}	3.73 ± 0.15^{abc}	3.89 ± 0.23^{ab}	3.30 ± 0.23^{bc}	3.13 ± 0.13^{c}
Crumb Texture	4.20 ± 0.26^{a}	3.53 ± 0.21^{ab}	3.69 ± 0.25^{ab}	3.60 ± 0.25^{ab}	3.33 ± 0.15^{b}
Crust colour	4.06 ± 0.22^{a}	3.33 ± 0.23^{a}	3.33 ± 0.25^{a}	3.53 ± 0.27^{a}	3.46 ± 0.19^{a}
Taste	3.93 ± 0.22^{a}	3.46 ± 0.13^{a}	3.73 ± 0.20^{a}	3.53 ± 0.23^{a}	3.46 ± 0.25^{a}
Aroma	3.60 ± 0.23^{a}	3.66 ± 0.18^{a}	3.40 ± 0.25^{a}	3.73 ± 0.20^{a}	3.33 ± 0.18^{a}
Overall acceptability	4.28 ± 0.28^{a}	4.07 ± 0.19^{a}	3.85 ± 0.25^{a}	3.78 ± 0.26^{a}	3.78 ± 0.21^{a}

Values are means standard deviation of triplicate determinations.
Means in the same row with different superscripts are significantly different ($p < 0.05$).

XYR = 100 % wheat flour
YBE = 90 % wheat flour and 10 % fermented unripe-plantain flour
CQD = 80 % wheat flour and 20 % fermented unripe-plantain flour
KOJ = 70 % wheat flour and 30 % fermented unripe-plantain flour
PSA = 60 % wheat flour and 40 % fermented unripe-plantain flour

Microbiological quality of bread samples

Table 4 shows the result of microbiological analysis of the bread samples. Microbiological analysis of the bread samples showed an absence of viable microbial cells up to four days of storage. This might be as a result of the dough fermentation and baking temperature which was adequate in terms of destroying the micro flora of the flour dough. It also indicates that bread produced from these flours can store well for up to four days if adequately packaged. However, microbial growth was recorded on the fifth day of storage. This might be due to the growth of microorganisms which survived the baking process and were able to act as soon as conditions became favourable again.

Table 4: Total microbial count of bread samples in storage

	Sample				
Day	**XYR**	**YBE**	**CQD**	**KOJ**	**PSA**
1	Nil	Nil	Nil	Nil	Nil
2	Nil	Nil	Nil	Nil	Nil
3	Nil	Nil	Nil	Nil	Nil
4	Nil	Nil	Nil	Nil	Nil
5	1.2×10^{2a}	1.1×10^{3a}	1.2×10^{3a}	1.0×10^{2a}	1.3×10^{3a}

Values are means ± standard deviation of triplicate determinations.

Values in the same row with different superscripts are significantly different ($p < 0.05$).

XYR = 100 % wheat flour
YBE = 90 % wheat flour and 10 % fermented unripe-plantain flour
CQD = 80 % wheat flour and 20 % fermented unripe-plantain flour
KOJ = 70 % wheat flour and 30 % fermented unripe-plantain flour
PSA = 60 % wheat flour and 40 % fermented unripe-plantain flour

Conclusion

Substitution of wheat flour with fermented unripe flour in bread making resulted in reduced loaf volume as well as loaf weight. Sensory scores for attributes such as crumb colour and texture were only significant at 40% level of substitution while sensory scores for taste, aroma and overall acceptability were not significantly affected at all levels of substitution. Although mean sensory scores decreased as plantain flour level increased, all the bread samples were acceptable. Substitution of wheat flour with fermented unripe plantain flour had no effect on the keeping quality of bread. The result shows the possibility of substituting wheat flour with fermented unripe flour for bread production up to 40 % level of substitution. This will help to diversify the food use of plantain as well as reduce post-harvest losses and conserve foreign exchange spent on wheat importation in the country.

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